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DAMAGE BY TERMITES IN THE CANAL ZONE AND PANAMA AND HOW TO PREVENT IT.

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INTRODUCTION.

In a preliminary paper Dietz and Snyder (*2*)[2] have given an historical survey of the status of the termites of Panama and have written of their habits and ravages to both living vegetation and the woodwork of buildings as well as to other works of man. This bulletin gives additional original data on the habits of the termites of this region, the damage they do, and their control. In the case of some of the species recently described by Snyder (*8, 9*) there has been no knowledge of their habits—and they are very injurious—since they had been confused with other known termites. Special attention has been given to damage by termites to lead-sheathed cables in conduits in locks of the Panama Canal and at other localities in Panama, as well as damage to telephone and lighting equip-

[1] The field notes were made by Mr. Zetek and the specimens were collected by him and by Ignacio Molino. All the determinations were made by Doctor Snyder, who has also helped to interpret the field notes and has prepared the manuscript.

[2] Reference is made by number (italic) to "Literature cited," p. 25.

ment. Such damage has been caused by *Leucotermes tenuis* Hagen, *Coptotermes niger* Snyder, and *Nasutitermes ephratae* Holmgren.

There is also a discussion of the possibility of termites acting as mechanical carriers of the nematode *Aphelenchus cocophilus* Cobb, which causes "red-ring" disease of coconut palms. Although species of Nasutitermes, Eutermes, and Coptotermes infest the trunks of coconut palms or have runways on them, only *Coptotermes niger* Snyder has been found with these nemas on the bodies of the workers.

As in the Dietz-Snyder paper (*2*), all specimens were given numbers in the field. All field observations and photographs of nests, galleries, damage, etc., are supported by numbered specimens of the termites. This insures accuracy and avoids confusion; it affords a check in case of wrong determinations, for the notes can then be identified easily and properly placed.

GEOGRAPHICAL DISTRIBUTION.

Apparently more species of termites inhabit the Pacific slope than the Atlantic slope of the Canal Zone. On the Atlantic slope the rainfall is greater. Mr. Zetek states that at Colon, in 1913, there were 246 rainy days, whereas at Ancon there were only 180, and the total precipitation was 131.22 inches and 65.98 inches, respectively; he has prepared a table (Table 2) giving the rainfall for 1921 for the 13 towns, with comments. This is particularly interesting, especially since many termites are so dependent upon moisture.

Reference to a map of Panama (Pls. I and II)[3] will show the Rio Chagres flowing practically southwestward, and receiving tributaries from both the north and south sides. Along the Atlantic side are rivers that empty into the Caribbean Sea and along the Pacific coast are rivers that enter the Gulf of Panama. There are, then, two more or less parallel divides, the first skirting the Atlantic coast, the second skirting the Pacific coast. Most people seem to have the erroneous idea that there is but one divide.

The Hydrographic Office, Bureau of Navigation, Department of the Navy, considers the central section as from Culebra (more or less near Pedro Miguel) to Monte Lirio. This is based on the original divisions made by the chairman of the Isthmian Canal Commission when the canal was being built. The central region is not considered by the present writers to extend beyond Darien.

Zetek has thus divided the Canal Zone into three regions—the Atlantic (as far as Darien), the central (from Darien to Pedro Miguel), and the Pacific (from Pedro Miguel to Panama). The great Gatun Lake has, of course, greatly altered this arrangement, and it may be necessary to change these limits somewhat. The central zone is a sort of transition zone, now less evident than when the digging of the canal was begun. The flooding of Gatun Lake killed the trees, and the insects had to go elsewhere and adapt themselves to new surroundings, or else die out. They emigrated in great numbers, no doubt, and a large proportion did well in their new abodes after some fighting with those already in possession.

[3] The map shown in Plate II is adapted from Plate I in Mammals of Panama, by E. A. Goldman (Smithsonian Miscel. Col., vol. 69, no. 5, 1920).

At first it was believed that a dense jungle bordering the canal would be ample protection against a foe. Later, a United States military officer found that his men could go through a dense jungle rapidly and with precision and without making much noise. It was then decided to clear away the jungle and have pastures and plantations in its place. The jungle was therefore cut down, allowed to dry, and then burned over. This radically destroyed insect habitats and killed off immense numbers of insects. Those that escaped had to go elsewhere; and as the plantations were started, many species found these good habitats and became more destructive to crops and to structures of man.

Much more collecting will have to be done before it is possible to do much generalizing on the distribution of termites in the Republic of Panama. The interior region should yield interesting termites. The termite mound nests described by Dudley and Beaumount have never been refound.

Table 1 gives the distribution of only those specimens of termites which were the basis for this bulletin.

TABLE 1.—*Geographical distribution of termites in the Canal Zone and Panama.*[1]

Family and species.	Locality.	Atlantic slope.	Pacific slope.	Both slopes.
Kalotermitidae:				
Kalotermes tabogae Snyder	Taboga Island, Republic of Panama.		X	
Cryptotermes thompsonae Snyder	Ancon, Canal Zone		X	
Rhinotermitidae:				
Leucotermes tenuis Hagen	Ancon, Canal Zone		X	
	Chitre, Republic of Panama		X	
	Miraflores, Canal Zone		X	
	Panama City, Republic of Panama.		X	
	Venado Plantation, Canal Zone		X	
Coptotermes niger Snyder	Ancon, Canal Zone		X	
	Cristobal, Canal Zone	X		
	Frijoles, Canal Zone	X		
	Miraflores, Canal Zone		X	X
	Panama City, Republic of Panama.		X	
	Pedro Miguel, Canal Zone		X	
	Summit, Canal Zone		X	
Termitidae:				
Nasutitermes cornigera Motschulsky.	Ancon, Canal Zone		X	
	Chitre, Republic of Panama		X	
	Frijoles, Canal Zone	X		
	Miraflores, Canal Zone		X	X
	Panama City, Republic of Panama.		X	
	Taboga Island, Republic of Panama.		X	
	Venado Plantation, Canal Zone		X	
Nasutitermes ephratae Holmgren	Ancon, Canal Zone		X	
	Matias Hernandez, Republic of Panama.		X	
	Miraflores, Canal Zone		X	
Nasutitermes columbicus Holmgren.	Frijoles, Canal Zone	X		
Subulitermes reteki Snyder	Summit, Canal Zone		X	
Anoplotermes gracilis Snyder	Alhajuela, Panama[2] (Upper Chagres River Basin).		(?)	
Eutermes debilis Heer	Ancon, Canal Zone		X	
	Taboga Island, Republic of Panama.		X	

[1] This table gives only the distribution of the specimens of termites which were the basis for this bulletin.
[2] Central interior

TABLE 2.—*Rainfall in the Canal Zone and Panama in 1921.*

Month.	Pacific section.				Central section.					Atlantic section.			
	Taboga Island.	Balboa.	Miraflores.	Pedro Miguel.	Culebra.	Empire.	Gamboa.	Juan Mina.	Frijoles.	Monte Lirio.	Gatun.	Colon.	Porto Bello.
1921.	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*	*Ins.*
January	1.53	1.49	0.26	0.04	0.03	0.15	0.09	0.23	2.50	3.32	2.01	1.31	4.21
February	.65	3.14	.76	1.53	.84	1.58	5.39	1.05	4.19	2.93	2.74	1.63	5.20
March	.58	3.29	1.46	.17	.36	.52	.09	.03	1.07	.26	.79	.98	2.57
April	.92	1.90	1.91	1.17	.42	.65	1.16	2.38	4.87	6.63	4.69	7.43	6.61
May	8.05	8.28	7.78	8.72	6.12	7.28	5.89	4.43	10.73	9.76	14.08	13.61	17.46
June	4.87	7.20	7.67	9.31	9.51	9.36	12.81	11.87	16.49	15.23	13.23	15.18	18.77
July	4.32	8.92	7.08	7.02	11.02	11.72	11.33	16.05	16.74	15.50	13.17	10.49	13.59
August	8.25	9.38	9.94	9.41	12.57	13.90	15.68	19.80	15.70	15.41	19.73	18.45	30.32
September	5.32	3.28	5.27	7.26	9.94	7.85	10.48	13.52	13.94	15.69	13.71	11.21	10.65
October	11.25	14.76	14.30	11.06	10.58	13.65	11.83	18.42	9.79	9.28	9.09	8.27	4.84
November	3.45	5.20	5.09	8.78	11.99	10.47	6.96	8.85	19.37	22.26	21.04	19.96	31.34
December	4.28	4.81	4.13	3.42	4.86	4.39	4.42	3.88	7.19	8.87	9.03	6.50	9.53
Total	53.47	71.65	65.65	68.39	78.24	81.52	86.13	100.51	122.58	125.14	123.31	115.02	155.09
Station average	51.75	67.95	78.59	79.32	86.84	80.90	90.79	95.03	101.77	118.85	120.00	127.85	160.00
Number of years of record	7	23	13	14	31	17	39	11	10	14	17	51	10
Number of rainy days	103	173	163	190	176	224	227	?	?	248	267	252	308

Rainfall for the year was slightly above normal over the Pacific coast and the greater part of Gatun Lake, and slightly below over the Atlantic coast and southern part of the central section. January and March were the months of least rainfall. August and November were generally months of greatest rainfall. The 1921 dry season was not very dry, as has been the case during some past years.

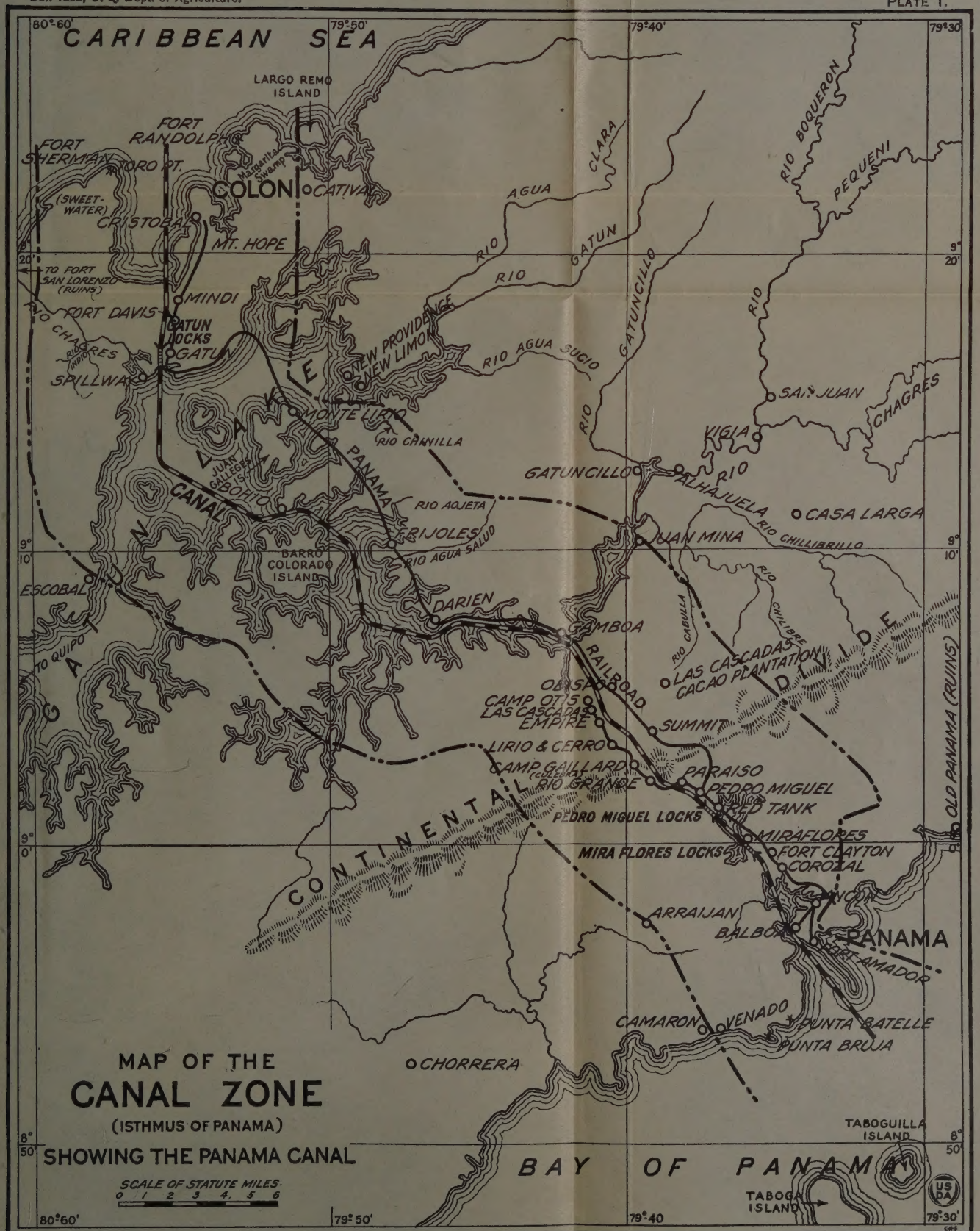
RELATIVE DAMAGE BY THE FAMILIES OF TERMITES.

Species in the family Rhinotermitidæ are apparently the most injurious termites in Panama, although very destructive species occur in the families Kalotermitidæ and Termitidæ. Damage by species in the family Rhinotermitidæ include injury to living trees, the woodwork of buildings and other timber, and damage to lead-sheathed cables. Species in the family Kalotermitidæ are very injurious to the dry woodwork of buildings and furniture in buildings, whereas species in the family Termitidæ are injurious to living fruit, coconut, and other trees, the woodwork of buildings, fence posts, and telephone and lighting equipment.

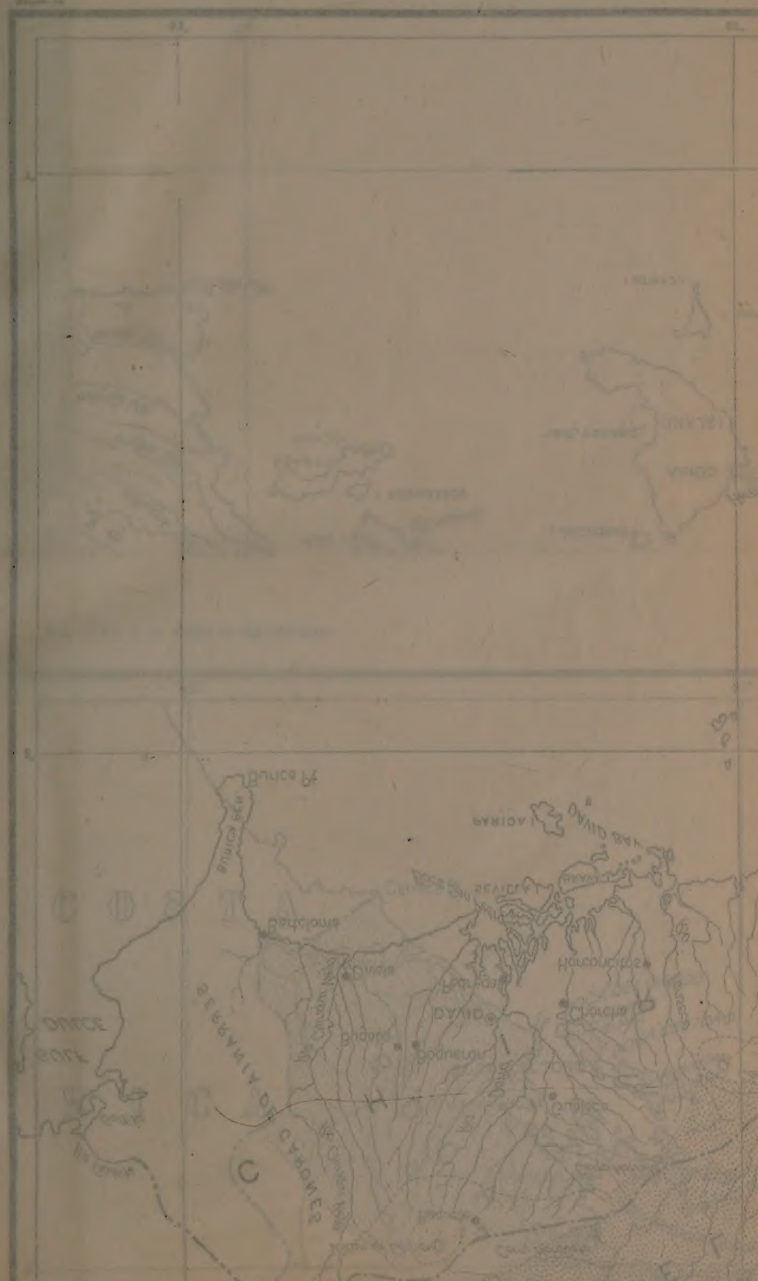
Damage by termites is serious on both the Atlantic and Pacific slopes.

Sometimes, particularly in case of furniture in buildings, it is difficult to determine what species of termite is responsible for the damage without destroying the infested article. This is due to the fact that soldiers or winged or deälated adults have to be found in order to identify the insect. In other cases, when the owner finds furniture or books damaged by termites his wrath is so great that he destroys the articles without saving specimens of the termites. This was the fate of a volume of La Salle law books destroyed by termites on a shelf in a building in Panama City (Pl. X, *C*).

Aside from the damage done by termites to the woodwork of buildings and their contents, the flight of the winged termites is a great annoyance in Panama. When these termites swarm or fly in great numbers, as has been noted at several localities in Panama, notably



MAP OF THE PANAMA CANAL AND CANAL ZONE, SHOWING LOCATION IN THE REPUBLIC OF PANAMA.



at Las Sabanas, which is the "summer" section for the fairly well-to-do Panamans, where they have their cottages and much land, they are a great nuisance. The native Panamans go to Las Sabanas after the carnivals if these are held early in the year, i. e., at the commencement of Lent. If the Lenten season begins late, they go as soon as the dry season begins, and for the carnival season return to their city homes. As soon as the rains start, these "palomitas"[4] begin to appear and the people take their presence as a warning to return to the city, as rains are coming fast. Those who heed not this warning find that they must eat early and hurriedly and even then it is a battle with these clumsy insects. The people say these winged termites "drive them crazy," and they certainly make them more nervous and increase their neurasthenia; the hurried eating and constant thought of the pests, fighting them off, or dishing them out of the soup or sancocho, produce marked digestive disturbances.

KALOTERMES TABOGAE Snyder.

Specimens of Kalotermes collected at Panama at first appeared to be identical with *K. marginipennis* Latreille, which occurs in the southwestern United States; nevertheless, it is a new species. *K. tabogae* works in dry woodwork and is destructive. As in the case of species of Cryptotermes, its presence can be recognized by the impressed pellets of excrement expelled from infested wood, as well as by the small round holes in the wood—entrance and exit tunnels. These pellets are called "carcoma" in Spanish, and furniture so destroyed is said to be "carcomido." In the majority of cases the native does not recognize this as termite (comejen) work, but thinks that it is caused by a different insect which he terms "carcoma," and until this fine distinction in terms is learned an argument is the usual result.

Very probably much damage to woodwork credited to this species in the past, before the identity of other and new species was recognized, was caused by other species, especially those of the genus Cryptotermes.

At Taboga Island, Republic of Panama, on March 30, 1922, Zetek collected winged sexual adults of *Kalotermes tabogae* attracted to a lighted kerosene lamp. At that date the dry season was at about its height. The rainfall record (in inches) for 1922 was as follows: January 1, 0.45; 2, 0.35; 3, 0.13; 9, 0.10; 17, 0.07; 23, 0.10; 31, 0.04 (an excess of 0.81 inch over station average). February 8, 0.06; 17, 0.09; 21, 0.10; 22, 0.02; 26, 0.20 (an excess of 0.31 inch over station average). March 21, 0.03 (a deficiency of 0.08 inch over station average). April 7, 0.08; 9, 0.09 (a deficiency of 1.12 inches over station average).

Of course, species of the family Kalotermitidae do not depend so much upon moisture for their existence as do termites of the other families.

At Ancon Hospital grounds, Ancon, Canal Zone, on June 19, 1922, Zetek and Molino collected deälated adults in a dead tree on which there was loose bark perforated with numerous holes of a scolytid beetle. The termites were in burrows identical with those of the

[4] "Palomitas de San Juan" is the full native name for any dark-colored flying termites.

scolytid, but showing additional enlargements. This is the same tree on which workers and soldiers of *Eutermes debilis* Heer were collected on October 26, 1921, from shelter tubes. Workers and a few soldiers of *E. debilis* were again collected on June 19, 1922; soldiers were scarce.

CRYPTOTERMES THOMPSONAE Snyder.

Several species of Cryptotermes occur at Panama, but *C. thompsonae* is the only one on which the writers have any biological notes. It is very destructive to the dry woodwork of buildings.

On July 25, 1921, Zetek and Molino collected soldiers and winged and deälated sexual adults of *Cryptotermes thompsonae* from a poplar case (Pl. III, *D*) in the office of the Board of Health Laboratory at Ancon, Canal Zone. This wooden case is a survival of the equipment of the old wooden hospital and was put into this ward when the new hospital building was completed. The termites were mostly in the baseboard. The winged forms were not very abundant and were congregated in small "pockets;" the soldiers were not aggressive or plentiful.

Zetek found soldiers and deälated sexual adults in hard beech wood of a drawer of a desk in Section B of Ancon Hospital on August 30, 1921. The desk had been in this screened concrete building for five years (Pl. III, *A*).

The dry hardwood of a back panel of an organ in the Roman Catholic Chapel at Ancon, Canal Zone, was found by Zetek, on October 19, 1921, to be damaged by this termite. The insects had gone into nearly all parts of the wood (Pl. III, *B*). No winged forms were present and soldiers were very scarce; nymphs of the sexual adults were abundant. Out of the back of this organ as much as 500 cubic centimeters of impressed pellets of excrement (Pl. III, *C*) could have been obtained; the actual size of these pellets is 0.85 by 0.54 millimeter.

Deälated adults were collected on June 19, 1922, under bark on the trunk of a dead tree on the Ancon Hospital grounds.

LEUCOTERMES TENUIS Hagen.

Species of Leucotermes are very similar in habit to species of Reticulitermes. Nevertheless, unlike the latter, they consistently line their galleries with white excrement (not spotted) and live in association with other insects. Earthlike shelter tubes (Pl. IV, *A*, *B*, *C*) are constructed by species of both genera. Two species of Leucotermes occur in Panama, namely, *tenuis* Hagen and *convexinotatus* Snyder; apparently these species do not greatly differ in their habits; each species occurs on both the Atlantic and Pacific slopes. Species in this genus not only injure living vegetation and the woodwork of buildings, but also damage lead-sheathed underground cables.

On August 10, 1921, Zetek and Molino found a nest on the trunk of a coconut palm on the Venado Plantation, Venado, Pacific slope, Canal Zone. The termitarium was about 8 inches by 5 inches, of earthlike material, soft outside and harder within, and composed largely of cells. This "nest" was partly within the trunk—about 2 inches. It contained workers, soldiers, and a first-form queen

with abdomen greatly distended; this queen measured 22 millimeters in length and 4.5 millimeters in width. The shelter tunnels were small, about one-fourth inch in width.

Leucotermes tenuis was found on November 15, 1921, infesting redwood window sills and frames at Ancon. These sills faced the inner court of the board of health laboratory and supported the 18-mesh wire screens. The termites were on both the first and second floors and in both places were making covered galleries along the concrete side, in a downward direction. In 24 hours they constructed from 8 to 15 inches of these galleries. On the first floor the galleries were in the direction of the drain pipe, and although repeatedly brushed away, were always reconstructed in the same general direction. The screens are always well wetted with a hose every Friday, so as to be clean of dust, etc., and consequently the wooden sills also get wet. The redwood quarter-round was taken out and found to be decayed in places and wet. The sill proper, of 2-inch material, was not flush against the concrete, hence was not very wet, excepting where the small wedges held it in place. The termites were only in the decaying parts of the redwood, not in any sound wood. As a remedy, the affected sections of wood were cleaned of decayed and infested material, then wetted with a strong solution of sodium fluorid, and new quarter-round strips put in, the flat surfaces of which were painted with the sodium fluorid. To date (June 20, 1922) there have been no further signs of the termites. This, of course does not necessarily imply that the sodium fluorid was responsible for repelling them. No termitarium was found anywhere.

At Ancon, Canal Zone, on November 23, 1921, workers and a very few soldiers of this termite were found in an old piece of discarded wood of a stairway. This indicates a habit similar to that of species of Reticulitermes which will infest any wood, sound or decayed, lying on or in contact with the ground for even short periods of time.

On November 29, 1921, Zetek and Molino found workers and soldiers of this termite in Spillway Tunnel, Miraflores, Canal Zone, 70 feet below the surface. These termites were found only in the west end of this long tunnel, and apparently had entered through that end, following the stairway, along the walls. Their galleries along these walls were very numerous (Pl. IV, *A*, *B*, *C*). The top of the tunnel is a flat arch, and at the west end there is a tall vertical shaft leading to the floor of the entrance to the tunnel. Where the ceiling of the flat arch meets the vertical shaft wall it was found that in several places the termite galleries, which followed the surface

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DESCRIPTION OF PLATE IV.

INJURY BY THE TERMITE *Leucotermes tenuis* TO LEAD-COVERED CABLES AT MIRAFLORES LOCKS, C. Z.: *A*, View along concrete wall in tunnel in spillway, 70 feet below surface, showing characteristic galleries. Black circle is hole left after a piece of wood was taken out. This wood was completely tunneled by the termites. Small black spots on concrete are bits of crude oil or paint. November 19, 1921. *B*, *C*, Characteristic views of termite galleries, taken by E. St. Clair Clayton by flashlight, in tunnel below spillway. Galleries were very numerous, standing out in bold relief upon white concrete. In places they were seen to lead to moisture. November, 1921. *D*, *E*, Flashlight views of tunnels of termite *L. tenuis* to show how sometimes shelter tubes project into space, forming branching structures. Workers were seen frequently in openings at ends of these tunnels, building them up further. View taken in long tunnel below spillway at Miraflores, 70 feet below surface. White part is concrete ceiling of tunnel, dark portion is space—a vertical shaft leading to surface 70 feet above. November 19, 1921.

of the ceiling, had been built out into space, forming weird branching effects (Pl. IV, *D*, *E*). The workers were seen at the ends of these free galleries, adding particles to them. The longest of these very unusual and interesting free, branching shelter tubes measured exactly 5 inches from the point of attachment to the free end. Along the concrete walls, where the galleries were scraped off, small holes made by these termites right into the concrete were found in places. These holes were usually at an angle of about 45° to the surface, and in one case almost 1 millimeter in depth, although the majority were only about one-half millimeter deep. In all probability these intrusions into the concrete are made only in soft places, and the writers do not believe that any process of solution, due to the liquid ejected from the mouth or frontal gland opening of the termites, is involved. Additional notes are given in the legends to the photographs (Pl. IV) illustrating this species.

This termite was found also in a manhole opposite lamp post 600, east wall, Miraflores Locks, Canal Zone (lake side) on the same day. They were along the concrete and along the lead-sheathed cables in the manhole.

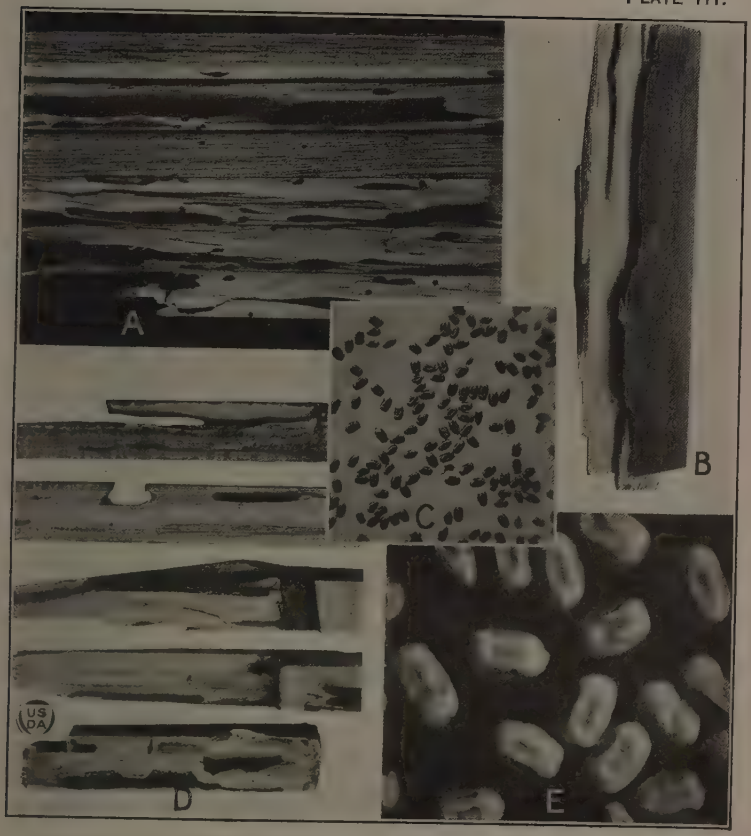
On November 30, 1921, Zetek and Molino found shelter tubes of *Leucotermes tenuis* in the restaurant of Ancon Inn, Panama City, J Street, near to Ancon, Canal Zone. Several good termite galleries were seen starting from the cross timbers of the ceiling and continuing down the walls. In one case the gallery as it left the timber was suspended in the air and was not attached to the wall until a point about 11 inches from the timber was reached; from this point, however, it descended the wall. In another case about 16 inches of shelter tube was free from attachment to the wall. At 10 p. m., November 29, a mark was made at the end of one of the wall galleries. The next day at 10 a. m. this was inspected and it was found that in this 12-hour interval the termites had built 12½ inches of additional gallery. At the opening of the gallery, but protected by the walls of the tube, two soldiers were stationed. The slender workers came out of the tube, sometimes as much as twice the length of their bodies, and with their mouths deposited something resembling flyspecks on the wall surface. From one to three workers came out at the same time and did not appear to be troubled by the light. Other workers were seen to add small pellets to the still fragile end of the built tube. On scraping the gallery, parts of the plaster and concrete were found into which the termites had made impressions, but these were extremely shallow, not over 0.25 millimeter deep.

INJURY TO LIVING CROPS.

On April 25, 1922, Zetek found *Leucotermes tenuis* infesting sugar cane on La Chironga Farm, near Chitre, Republic of Panama. The infested cane is usually brownish in color, and the damage was frequently from 10 to 35 per cent. Thus far this appears to be the most serious sugar-cane pest in Panama.

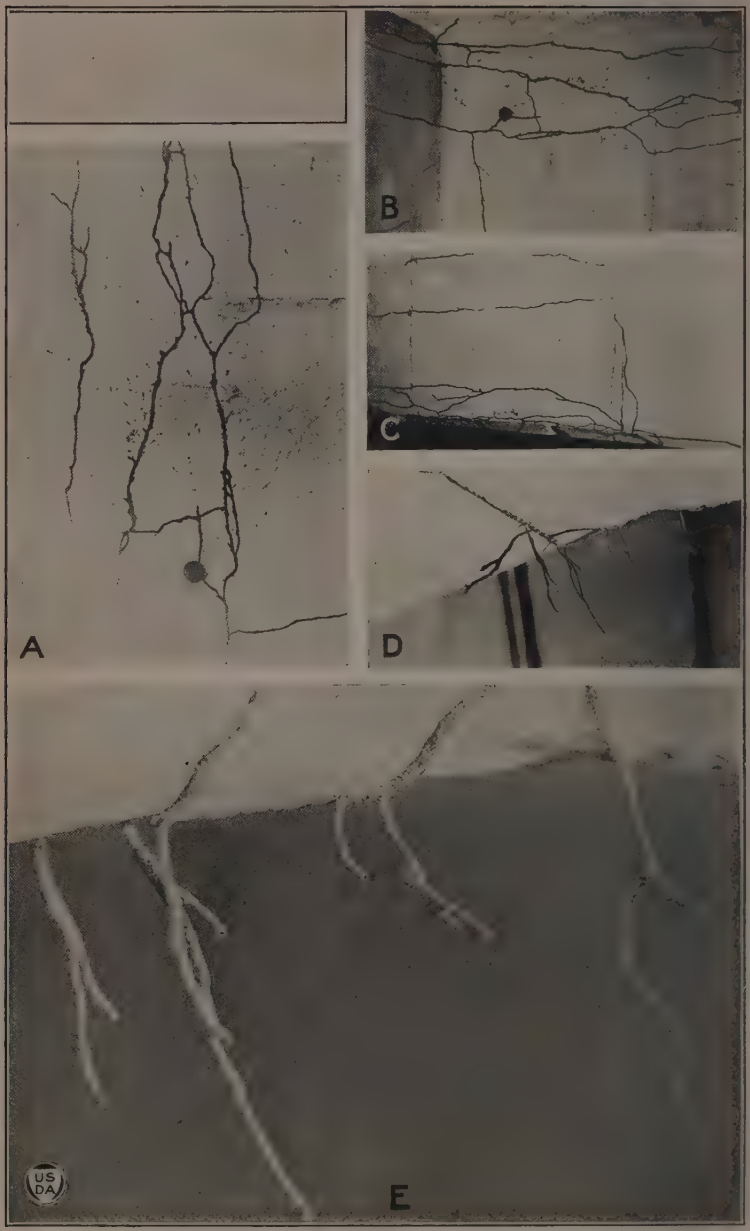
COPTOTERMES NIGER Snyder.

As was predicted, *Coptotermes niger* is proving to be one of the most destructive termites of Panama. These termites injure living



DAMAGE BY KALOTERMITDAEI TO THE DRY HARD WOOD OF FURNITURE IN BUILDINGS.

A, Hard beech wood from a drawer of a desk damaged by *Cryptotermes thompsonae*, in a building at Ancon, C. Z. *B*, Back panel of an organ in a chapel at Ancon, damaged by *C. thompsonæ*. *C*, Pellets of *C. thompsonae* near natural size. *D*, Wood from poplar case damaged by *C. thompsonae* in a building at Ancon, C. Z. *E*, Impressed pellets of excrement of *C. thompsonae*, greatly enlarged; actual size, 0.85 by 0.54 millimeter.



INJURY BY THE TERMITE LEUCOTERMES TENUIS TO LEAD-COVERED CABLES AT MIRAFLORES LOCKS, C. Z.

Description at foot of page 6.

INJURY TO LEAD-COVERED CABLE BY THE TERMITE COPTOTERMES NIGER AT MIRAFLORES LOCKS, C. Z.

Description at foot of page 10.

DAMAGE TO LEAD-COVERED CABLES BY THE TERMITE COPTOTERMES NIGER.

A, Tape, rubber, and paper insulation perforated; near Cristobal. *B*, *F*, Damage to wood form under concrete wall cover to tunnel through which cables run at Miraflores Locks. *C*, Damage to lead cable and insulation on this tunnel. *D*, Galleries of *C. niger* in trunk of cocoanut palm at Ancon, C. Z. *E*, Swarm of colonizing sexual adults of *C. niger*, showing workers and soldiers; from central wall, central tower, Miraflores Locks. *G*, Shelter tubes of *C. niger* on avocado tree at Frijoles, C. Z.

vegetation, woodwork of structures, and lead-sheathed cables. A white, thick liquid is secreted from the frontal gland opening in the head of the soldiers which serves as an effective material of defense.

On July 26, 1921, Zetek collected soldiers and workers in galleries on the trunk of a black palm at La Loceria, Tumba Muerta Road (near Corundu River), near Panama City. These galleries were made of red earth and were thick, rough looking, flat, baked from the heat, and cracked; the main ones were from 4 to 8 inches wide and about one-half to three-fourths inch thick. From the main galleries smaller ones branched off. The termites were in the wood of the palm tree also. The soldiers when uncovered stood their ground and made lively jerky movements.

On October 26, 1921, Zetek and Molino found soldiers and workers of *Coptotermes niger* on and in the trunk of an unknown tree at Ancon Hospital. The galleries consisted of a main one one-fourth to five-sixteenths inch wide, of earth, firm in texture, beginning at the earth surface and reaching to about 2 feet above, then bifurcating, one branch leading to one "seminest,"[5] the other to another one. These "seminests" were of earth, with galleries, firm, about 2 inches by 4 inches in size, and extending about 1 inch into the wood. Many soldiers but few workers were present in the tunnels and wood. Several small "seminests" of earth, hard and brittle, were found in small hollows in the trunk of a "mamey de tierra" tree (*Lucuma mammosa* Gaertn.), at Ancon Hospital on this same day by Zetek and Molino. These nests were about 2 inches to 3 inches by 1 inch to 2 inches thick, and from them tunnels extended into the wood of the trunk. Scratching the bark of the tree brought out the soldiers.

INJURY TO LEAD-SHEATHED CABLES IN THE LOCKS OF THE PANAMA CANAL.

On November 7, 1921, Zetek and Molino collected specimens of *Coptotermes niger* in the center wall of Miraflores Locks, Canal Zone. The insects had eaten into the lead sheathing of the duplex cables. This damage to the lead was first noted about November 1, when the telephone service was unsatisfactory. R. S. Mills, acting assistant superintendent of the Pacific locks, then in charge of the Miraflores section, and E. St. Clair Clayton, one of the operators in the control house at the Miraflores Locks, are responsible for calling attention to this injury and for helping in every possible way to get data, specimens of the insects and of the damaged cables, and photographs (Pls. V and VI). M. N. Shaw, cable splicer, first found this infestation about three weeks before the date (November 7, 1921) mentioned above. No positive data as to money value of the loss could be obtained. Fifty feet of duplex lead-covered cable had to be replaced and the cost of the cable, the salary and time of the cable splicer, etc., would easily amount to $100.

No. 12 stranded rubber and lead-covered duplex 600-volt cable is used for telephone service; for ringing, 110 volts 25-cycle alternating current is used; for talking, 24-volt battery current is used.

An 8-conductor braided and rubber-insulated lead-covered control cable, carrying 220 volts, 25-cycle, alternating current, was also at-

[5] *Coptotermes niger* does not construct regular external nests as do some termites, but builds earthlike nests in hollows in wood, as well as honeycombing the wood, in a manner similar to that of species of Reticulitermes.

tacked. This cable carried two spare wires (neutrals), not used. This was in the crossover wells, i. e., away below the floor of the lock chamber. In this case the cables have a certain definite twist and the termites followed the two spare, unused wires, and kept entirely away from the wires carrying the high-tension current.

It is the writers' opinion that much more damage was done, but that it was sporadic in nature, so that it was entered in the records only as repair work, of which there is always plenty.

The damage was confined particularly to one small section along the center wall of these locks, between two or three of the light posts. The duplex cable, which measures 9 by 19 millimeters on cross section, runs through conduit pipes that are 3½ inches in diameter (Pl. V, *A*). The particular type of injury is well illustrated in the photographs (Pl. V, *B–G*). As a rule, the termites had their galleries attached to the lead-covered cables. At places, for some reason or other, they worked into the lead, perforated it, and then traveled between the two insulated wires (Pl. V, *D*), there being some space between these wires. As this space is not wide enough, they chewed away the insulating material, including the rubber (Pl. V, *D*, *E*). The hole through the lead is usually enlarged on the inner surface. They travel thus between these two wires for spaces of a foot or so, sometimes only for a few inches, and then emerge again and build the galleries along the outside of the lead cable. It is estimated that there was a hole every foot or so (Pl. V, *B*, *C*, *G*). The particular damage to the service is due to the entrance of moisture through these holes.

In another instance these termites cleaned off on the duplex cable a section about 15 inches in length along the narrow edge, thus giving the cable a flat surface and making it look very much as if it had gone through a shaper machine, excepting that the surface was not very smooth. (Pl. V, E.)

The center wall of the locks consists of a main tunnel near the surface, extending only as far as there are lock gates. Since the center wall is prolonged farther than the two side walls, the outer part has no tunnel, but only manholes, some of these large recesses being big enough for a man to walk around in. Each manhole feeds two lamp-posts. It was at one of these that most of this damage was noted.

It was found that in these manholes and recesses plenty of moisture was usually present, and in most instances some of the timber was

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DESCRIPTION OF PLATE V.

INJURY TO LEAD-COVERED CABLE BY THE TERMITE *Coptotermes niger* AT MIRAFLORES LOCKS, C. Z.: *A*, View in one of larger manholes, in center wall of locks, showing ends of 3½-inch conduit pipes and duplex lead-covered cable coming out of these. Across second (middle) pipe is seen a termite gallery which started in the pipe above and is completely separated from the wall. Below middle pipe is seen continuation of it, about one-half inch suspended. Wandering galleries along concrete wall coalesce in places or become enlarged, forming small cavities in which termites congregate. Flashlight photograph by E. St. Clair Clayton, November, 1921. *B*, Four typical samples. In one case is seen a large area chewed away with part of insulation also gone. These are duplex telephone 7-strand cables. Holes occurred about every foot or so, the termites getting between the two insulated wires and traveling in this space, eating away part of insulation. Duplex cable measures 19 by 9 millimeters. *C*, Five pieces of duplex lead-covered telephone cable, showing holes made through lead sheathing by termites. *D*, Part of cable covering opened out to show runway of termites between two insulated wires, parts of insulation eaten away to rubber coverings and sometimes even this eaten away. *E*, Part of lead covering chewed away, also portion of insulation. In the second case termites chewed away a flat channel, about 12 inches long, along edge of lead cable. *F*, Another view of *D*, showing eaten-away insulation running whole length of wire in both cases and in one with more extended injury at site of opening. *G*, View of *D* and *F*, with only a portion of lead covering laid open, showing boring as first discovered.

that used in the forms when the locks were built. This timber has no purpose here, and all of it was infested, usually very badly, and nearly all termite galleries ran to some of this wood.

In the long service tunnel, in the center wall, some of the cables run in the space between the ceiling and walls—i. e., a niche was provided for this purpose. Small creosoted (dipped) blocks of wood had been put at regular intervals as wedges to prevent these cables from falling out. Plenty of termite galleries were found in this big tunnel, and in many instances these insects had gone to and were found in these creosoted blocks and did not seem to be repelled by the creosote. The termites had also damaged untreated oak and the native hard "bullet wood" braces.

In one case the termite gallery left one conduit pipe and was continued into space, forming a loop which found no attachment until it reached the lowest point in the next conduit below, and then started to make another loop. (Pl. V, *A*.) The direction was downward. In the tunnel, where one surface is perpendicular to another, cases were observed where the termites on reaching the next wall continued their tunnel into space; such cases were common, but always appeared to be abnormal and due to the conditions encountered. Such galleries were usually branched, as if the termites were trying to locate a surface for attachment.

The writers were told that at light post 750, after the first few rains of the 1921 rainy season, winged termites emerged from two places in the ground. No specimens were collected by the observers, but at a later date specimens were collected and proved to be *Coptotermes niger*. It was said that swallows (not nightjars) came down when this swarming was taking place and fed on these termites, and that they were not frightened by the presence of the men; in fact, that they even moved about between the feet of the men present. The birds not only caught the flying termites while on the wing, but also found the place from which these termites were emerging and, settling on the ground, captured and devoured them as they emerged.

The All America Cables (Inc.) have had trouble with their transisthmian cables due to damage by termites, and the following notes are taken from a conversation with G. W. Wetjen, jr., of this company: The company has a 4-core cable, lead covered, each core with a heavy rubber insulation, the lead covering protected first by a waterproof cloth, and on top of this a heavy waterproof, tough twine. This cable is buried in the ground and in places it goes through the water of the lake. It has been found that when this cable is buried close to the surface they have no trouble from termites, but when it is more than a foot below the ground there is trouble. This trouble is greater where trees are near by. In land reclaimed by filling no trouble has been discovered as yet.[6] The termites go right through the outer waterproof protections, through the lead, and through the rubber. The insects do not seem to like copper, for as soon as they have tried this metal they leave it. In some cases termites were found to be very plentiful, but usually when trouble is "picked up" the insects that caused it have gone or have been dispersed by the men making the preliminary excavations. Soldiers of *Copto-*

[6] Undoubtedly, however, there will be trouble later when the termites have invaded the soil.

termes niger were found in the damaged 4-core cable by Mr. Wetjen near Summit, Canal Zone, in November, 1921. Injury from termites to the company's larger cable, which goes through a concrete duct, has not yet been discovered.

A. Cooper, manager of the Cristobal office of the All America Cables Co., reported another case of damage to their cables by *Coptotermes niger* 5.3 miles south of Cristobal, 660 feet from the nearest splice, and in 2 feet of clay soil. The tape, rubber, and paper insulation were also perforated (Pl. VI, *A*). Workers and soldiers of *Coptotermes niger* were collected from the center wall, Miraflores Locks, Canal Zone, on May 15, 1922, by I. Molino and E. St. Clair Clayton. These termites were damaging lead-covered, 5-core, 7-wire cables, 220 volts, alternating-current, at section 705. In 1 foot there were 7 holes and in the next foot 3 holes. Six feet of cable had to be replaced. Here there was a concrete cover, 2 by 3 feet, over a small well 3 feet deep which communicated with a tunnel used for cables that connected the two side sections, of which No. 705 was one. Under this concrete cover was found some wood used for the forms when the concrete was poured. This was infested with termites.

Specimens of the termites inside of the lead-covered cable were collected as well as those in the wood. Specimens of the infested wood, of the damaged cable, and of damaged insulation (Pl. VI, *B*, *C*, *F*) were collected. All of this damage was caused by *Coptotermes niger*.

This injury to lead-sheathed cables is what might be termed a "local" damage. Such cases are not at all infrequent and occurred also at Pedro Miguel and Gatun. If all the wood had been removed at the proper time, however, there would have been none of this damage.

DAMAGE TO LIVING TREES.

Cases of damage to living trees by *Coptotermes niger* are as follows:

On February 4, 1922, Zetek and Molino collected specimens in avocado trees at Frijoles, Canal Zone. Galleries had been constructed on the trunks of the trees (Pl. VI, *G*). These were rough, made of clay, from 1 inch to 1¼ inches wide, and the cavity inside (or hollow) one-eighth inch to three-sixteenths inch in diameter. The termites also worked in the wood of the trunk, and a hole 4 inches deep containing inhabited galleries was observed. Knot holes and poorly pruned places in the trees where rot had already set in were specially sought by these termites. Soldier termites were very abundant.

DESCRIPTION OF PLATE VII.

INTERRELATIONSHIP BETWEEN NEMATODES, THE TERMITE *Coptotermes niger*, AND THE "RED-RING" DISEASE OF COCONUT PALM TREES: *A*, Palm C, Nurses' Quarters, Ancon, C. Z., July 7, 1922. This coconut palm had broken off about 2 feet from the ground and had fallen over between 6 p. m., July 6, and 8 a. m., July 7. *B*, Closer view of same palm, showing break at end of trunk and, at base, upper part of injury through which termites gained entrance into trunk where they had built a secondary termitarium. Part of the trunk at break soft, rot-like in texture, abundantly infested with nematodes. *C*, Smoothed face of section CC (see text fig. 1) of trunk. The red ring is very prominent. Nemas were present in all parts of the section. In the lower right-hand corner is a part of the termitarium. *D*, Covered runways of *C. niger* formed overnight after trunk had been sawed up into four pieces. Larger diameter of trunk about 16 inches. Injury through which termites entered palm is seen in upper part of picture.

On February 16, 1922, these termites were found by Zetek and Molino on a ceiba tree (*Eriodendron casearia* Medic.) at Pedro Miguel, Canal Zone. The galleries on the tree were of mud from one-half to 1½ inches wide, ragged looking, irregular, and flattened; those newly made were very wet and soft, the old ones dry and hard. The portion still under construction appeared to be the site of concentrated effort for a distance of 18 inches, as if the insects were trying to do as much as possible in as short a time as possible. The sides of this newly-constructed gallery were not complete, but had an opening for almost every inch, and at these openings large numbers of termite soldiers stood guard. These soldiers were practically all outside of the gallery, in direct light, with their mandibles wide open; they were aggressive, snapping at anything, and exuding in plenty the viscid white liquid. Inside of the openings were additional soldiers in reserve. As the gallery neared completion, the lower end was finished and all the side openings were closed.

Similar damage to the trunks of living coconut palms occurs (Pl. VI, *D*), and this is discussed in more detail under a subsequent heading (p. 15–16).

SWARMING.

Winged adults of *Coptotermes niger* were collected by E. St. Clair Clayton from the center wall north of the control tower, Miraflores Locks, Canal Zone, from a swarm which occurred on May 28, 1922. They were emerging at about 4.30 p. m., from a small hole in the ground, near a concrete lamp post, at the same place where there was a swarm the year before.

Another swarm of this termite took place in front of the board of health laboratory, Ancon, Canal Zone, at 3 p. m., May 28, 1922. The termites were coming from the crack between the concrete curb and the concrete walk in enormous numbers, the most important feature being the immense number of soldiers which lined the crack and immediate vicinity, remaining on guard as long as winged forms were emerging. The photograph (Pl. VI, *E*) was taken with an upright stand which was focused indoors, and taken outside already set up, since it was raining and the light was poor and unnecessary exposure of the camera to the bad weather was undesirable. Unfortunately, the focus was not sharp enough to give detail at a one-fifth second exposure.

A POSSIBLE MECHANICAL CARRIER OF THE NEMATODE APHELENCHUS COCOPHILUS WHICH CAUSES "RED-RING" DISEASE OF COCONUT PALM TREES.

There is evidence that *Coptotermes niger* may be a mechanical carrier of the nematode which causes "red-ring" disease of living coconut palms. A coconut palm (Pl. VII, *A*), about 5 years old,

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DESCRIPTION OF PLATE VIII.

INTERRELATIONSHIP BETWEEN NEMATODES, THE TERMITE *Coptotermes niger*, AND THE "RED-RING" DISEASE OF COCONUT PALMS: *A*, Covered runway of termite built overnight after trunk was sawed up into four pieces. At lower end is seen part of termitarium which had been cut through during sawing. The characteristic ring of the disease is very evident. This section is lower face of CC' of the diagram (text fig. 1). *B*, View of termitarium of termite found within trunk of palm. The tissues were abundantly infested with *Aphelenchus cocophilus*. No queen cells were found; only soldiers and workers were present. *C*, Another view of same termitarium. Note cylindrical runways of termites going into trunk tissues. *D*, *E*, Other views of same termitarium.

growing near the nurses' quarters at Ancon Hospital, Ancon, Canal Zone, and transplanted to this location about three years before, was inoculated with live nemas (*Aphelenchus cocophilus*) January 10, 1922, by Dr. N. A. Cobb, with the assistance of Mr. Zetek. Since Doctor Cobb left a few days later, the observations on the progress of

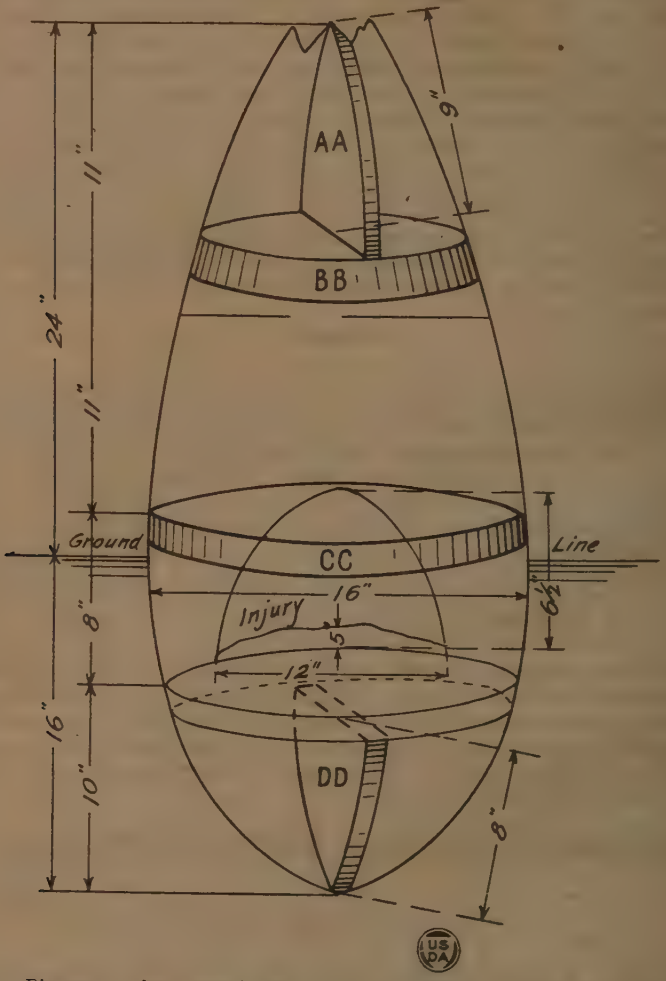
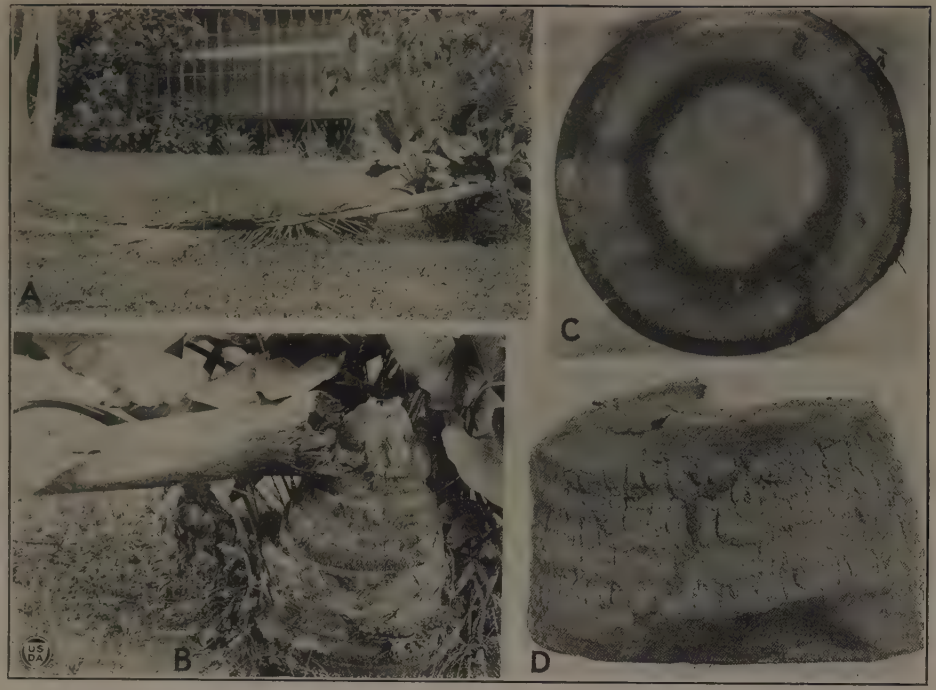


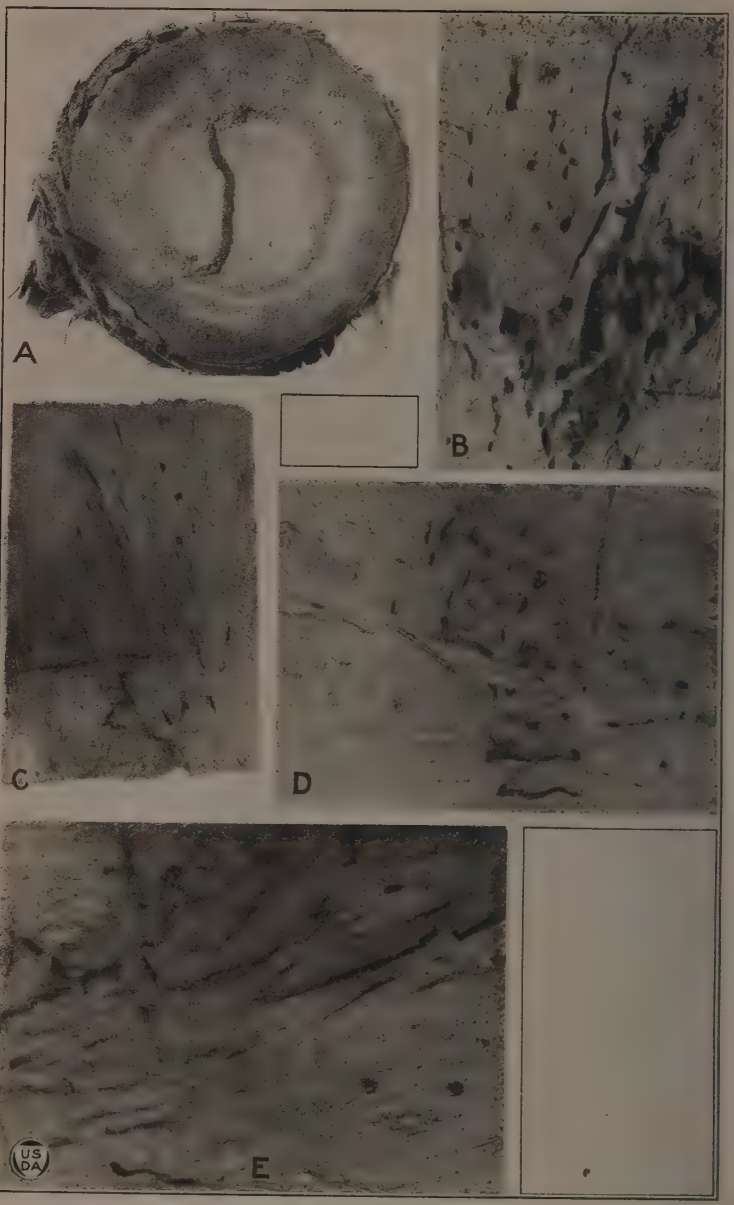
FIG. 1.—Diagram to show general shape and size of trunk of coconut palm shown in Plate VII, its relation to ground level, and location of four sections that were cut and photographed. Location of injury through which termites entered is also shown.

the disease were made by Mr. Zetek, assisted by Mr. Molino. The inoculation was made under aseptic conditions into two petioles and live nemas, free in a little water, were used. When transplanted the tree was placed too deep in the ground, but it was growing very well.



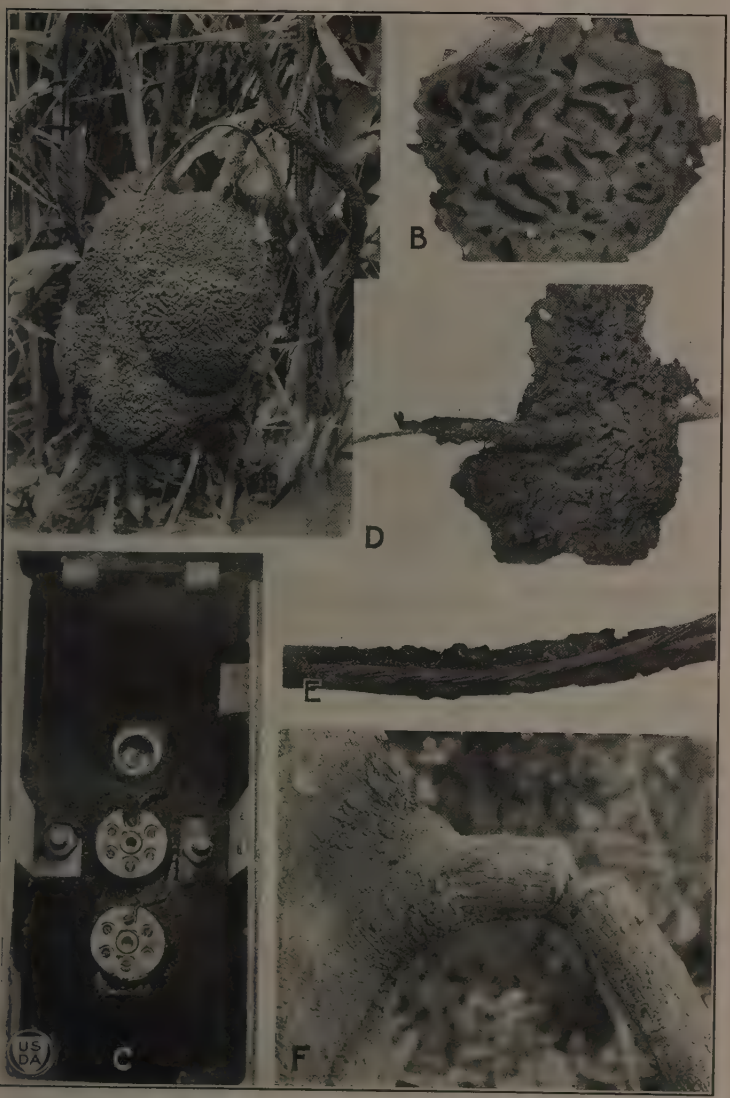
INTERRELATIONSHIP BETWEEN NEMATODES, THE TERMITE COPTOTERMES NIGER, AND THE "RED-RING" DISEASE OF COCONUT PALMS.

Description at foot of page 13.



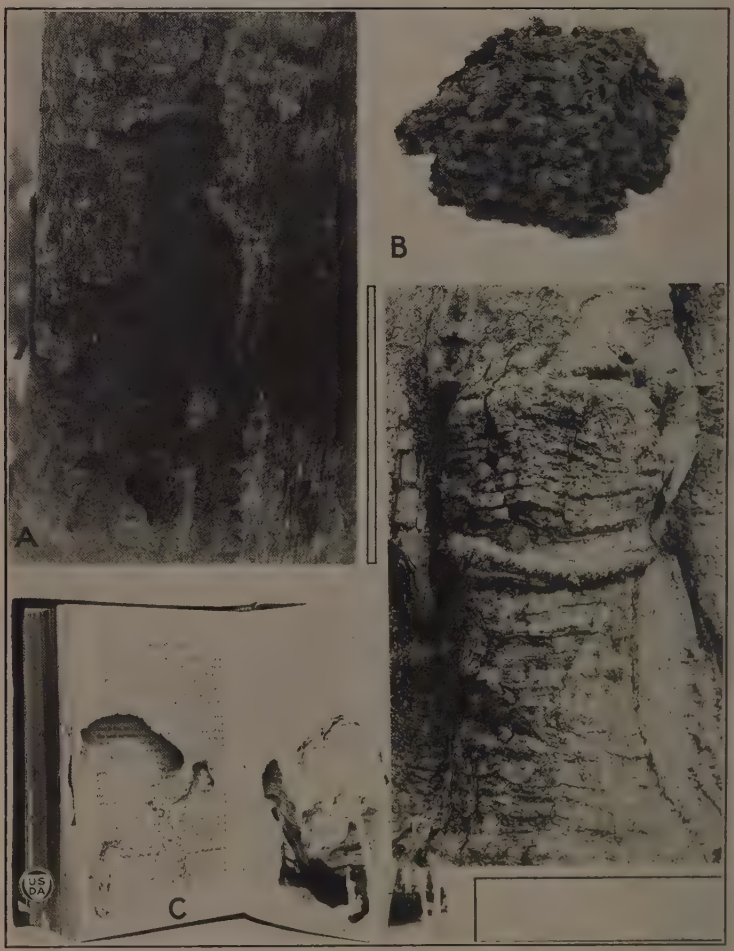
INTERRELATIONSHIP BETWEEN NEMATODES, THE TERMITE COPTOTERMES NIGER, AND THE "RED-RING" DISEASE OF COCONUT PALMS.

Description at foot of page 15.



CARTON NESTS AND SHELTER TUBES OF NASUTITERMES CORNIGERA AND INJURY TO ELECTRICAL APPARATUS BY N. EPHRATÆ.

Description at foot of page 17.



SHELTER TUNNELS AND NEST STRUCTURES AND DAMAGE BY TERMITES, ALSO THE TERMITELIKE SHELTER TUNNELS OF AN ANT.

A, Shelter tubes of *Nasutitermes columbicus* on avocado tree, Frijoles, C. Z. *B*, Part of nest structure of a termitarium of *Eutermes debilis* in crotch of tree on Taboga Island, R. P. *C*, One volume of LaSalle University law books, badly damaged by termites, on shelf in room. Three volumes were attacked. The damage seems to have been done in one week's time. *D*, Shelter tubes of an ant similar to those constructed by termites. Photographs by Zetek.

The history of the palm following inoculation was as follows: At first there was no indication of anything wrong inside. Then came a sudden rapid growth, which lasted a very brief time. The palm then took on an unhealthy appearance, which became more and more evident, so that people unaware of what had been done to the palm remarked that it did not look well. Early in June there was a browning and drying out of the tips of the leaflets, beginning with those nearest the apex and gradually working downward. The final collapse came July 7, i. e., almost six months after the inoculation, the palm breaking off 2 feet from the ground level.

The photographs show the palm after it had fallen. The close-up of the trunk (Pl. VII, *B*) shows at the base a slanting injury. The extent of this wound is better shown in the accompanying sketch (fig. 1), which gives the size and shape of the trunk, relation to ground level, and the location, size, and shape of the wound. This wound is of importance because it afforded entrance to termites. During the time the palm was being watched this wound was suspected of harboring termites, but there were no outward indications of their presence, and to have cut into the injury in search of them would have interfered with the experiment. There were no galleries up the palm trunk, but, as was discovered later, termites were present inside, having come up through the earth.

The termites were very abundant inside of the trunk, where they had formed a well-defined termitarium. Only soldiers and workers were present, however, and there were no signs of queen chambers. Five photographs were taken of a section through this termitarium which illustrate well its character (Pls. VII and VIII). Special attention is called to the runways in the shape of holes (Pl. VIII, *B*, *C*, *D*, *E*). At the widest part of the termitarium the termites filled about one-third the width of the trunk, or about 6 inches, but their tubular runways went to all parts, although none were seen as far up as *BB* of the sketch (fig. 1).

All of the tissue of the termitarium was abundantly supplied with live nemas. Individual termites were carefully picked up and washed in water, and by this means many live nemas which had been clinging to their bodies were recovered.

Since these termites had only a secondary termitarium in this palm, they must have had the main one elsewhere, and probably members of this same colony visited other palms in the neighborhood. The possibility of mechanical transmission of nemas to healthy palms by the termites is thus seen to be great. They may be carried in any stage, including eggs. Likewise, since in this case nemas were also in the roots, and it has been shown that nemas will live in the soil about an infested palm, termites are well able to become soiled with live nemas in the earth, and thus bring the infection to other palms.

The photo of section *CC* (Pl. VII, *C*), which is the upper side, shows a part of the termitarium (indicated by an arrow).

After the trunk had been cut into four parts, as shown in the sketch (fig. 1) (10 inches, 8 inches, 11 inches, and 11 inches), at 4 p. m., July 7, 1922, the four segments were left in the room till next day. At 8 a. m., July 8, Zetek found along the face of the second section (from top) a covered runway or gallery 7 inches

long built by these termites during the interval. A photograph was taken of this newly made gallery (Pl. VIII, *A*). Soldiers were on guard at the openings of this gallery.

There was also a gallery along the sides of the third section (from top); it measured 6 inches in length (Pl. VII, *D*). The wound is shown in the photograph of this segment. Section *CC* was cut from the top of this particular section.

No termites were found in section *DD* (fig. 1).

COMPOSITION OF SHELTER TUBES.

A microchemical examination by the Bureau of Chemistry of the United States Department of Agriculture of fragments of the shelter tubes constructed by *Coptotermes niger* from galleries in the center wall of Miraflores Locks, Canal Zone, is reported as follows:

Sample *B*. M. 38192. This sample was found to contain an appreciable amount of siliceous material, and also material giving the usual microchemical reaction for lignin, as well as showing evidence of definite cellular structure, thus differing from sample *A*, where similar material was more finely comminuted.

NASUTITERMES CORNIGERA Motschulsky.

The bad-smelling *Nasutitermes cornigera* is one of the most common and destructive termites in Panama, and its semispherical, "niggerhead," carton nests on the trunks or in the crotches of trees are often found.

On July 26, 1921, Zetek and Molino found this termite very abundant on trees along the Tumba Muerta road, near Panama City, from Las Sabanas road to Corundu River, a distance of about 1½ miles, it being the prevalent species. Citrus trees especially were badly infested. At Octavio Icaza's place nearly all the citrus trees had nests of this termite in the crotches. At Herbruger's place (La Loceria) all the citrus trees were infested with this species, which was very abundant and in two cases had apparently caused the death of the trees.

Earthlike galleries one-half to 1 inch wide and one-fourth to three-fourths inch thick were abundant on the tree trunks along the road referred to and nests in the trees were not rare. No queens were found, the nests containing mostly soldiers. In one case at La Loceria (near Panama City) on a citrus tree soldiers were seen crawling about and also exposed on the ground with no gallery or anything to protect them. A distance of about 4 feet was traversed in this manner.

Some of the nests on trees were as large as 2 feet by 3 feet.

DESCRIPTION OF PLATE IX.

CARTON NESTS AND SHELTER TUBES OF *Nasutitermes cornigera* AND INJURY TO ELECTRICAL APPARATUS BY *N. ephratae*; *A*, Large semispherical carton nest of *N. cornigera* at Miraflores Locks, C. Z. *B*, Structure of termitarium inside of bronze service box in Lamp Post No. 600, Miraflores Locks, C. Z. November 29, 1921. *C*, Termitarium of *N. ephratae* in hollow center of Lamp Post No. 600, Miraflores Locks, enveloping the wires, light socket, and two telephone sockets in bronze service box. There were, back of this nest, a few pieces of pine boards infested with this termite. November 29, 1921. *D*, A lead-covered 600-volt copper wire with termitarium about it. This termite does not eat into the lead, but does destroy all cloth and rubber insulation. Where the copper is laid bare the termites have formed a sheath over it. November 29, 1921. *E*, Damage done to braid and rubber insulation of 600-volt wires leading to overhead lights at Lamp Post No. 600, Miraflores, C. Z. *F*, Shelter tube of *N. cornigera* on branch of avocado tree showing work of a girdling beetle, *Trachydares subpilosus*.

These termites were also very abundant on fence posts along the same road on July 26. Hardly any posts were without their galleries and in many cases had carton nests as well. Soldiers in the main were seen and there were no queens.

Zetek and Molino found *Nasutitermes cornigera* in a wine palm (*Acrocomia vinifera*) at Ancon Hospital on October 26, 1921. These termites were very abundant throughout the wood of the trunk and along the midrib of fronds. Soldiers came out rapidly when the trunk was tapped with a piece of wood. Small nestlike structures were found sheltered by the pieces of leaves and bark, as also nests at the base of leaves; all these were soft and crumbly in texture.

On November 3, 1921, a nest of *Nasutitermes cornigera* was found in *Ficus crassiuscula* at Ancon Hospital, Canal Zone. The nasuti were very abundant.

A termitarium of this species was found in the top of a jobo tree (*Spondias lutea* L.) at Ancon Hospital, Canal Zone, on November 23, 1921. Galleries, which were fairly straight, were abundant, the narrowest one being about three-eighths of an inch wide, the largest 2 inches broad by one-half inch thick. The small ones joined to form wide ones. In the galleries nasuti or soldiers were very abundant and workers very few. This termite has a very pungent, disagreeable odor. When the soldiers were grasped or touched they emitted a milky fluid from the opening of the frontal gland or end of the nasus or beak. In many cases this shot out into space as a small droplet, the distance it was propelled in many cases being 1 foot. It did not seem to have any irritating effect on the skin.

At Miraflores, on November 29, 1921, Zetek and Molino found a termitarium of *Nasutitermes cornigera* on a tree on a small island near the locks. This termitarium was 12 inches by 18 inches in dimensions and had numerous galleries along neighboring branches (Pl. IX, *A*). Nasuti were very abundant in it. Zetek found it to be very hard and difficult to break up, although the machete he used was sharp and some impression could be made upon it with every cut. At the third blow, however, the machete glanced off and just missed badly cutting his foot.

On February 4, 1922, at Frijoles, Canal Zone, Zetek took an interesting photograph (Pl. IX, *F*) of a gallery of *Nasutitermes cornigera* on an avocado limb, showing the work of a girdling beetle, *Trachydares subpilosus* Bates.

A nest of this species in process of construction was found on April 1, 1922, in an avocado tree on Taboga Island, Republic of Panama.

From the foregoing it will be seen that *Nasutitermes cornigera* builds its carton nests in a variety of trees and is an injurious termite.

SWARMING.

Winged adults of *Nasutitermes cornigera* were collected flying in a house in Chitre, Republic of Panama, during the afternoon of May 7, 1922, during a heavy rain—the first of the rainy season at this locality.

NASUTITERMES EPHRATAE Holmgren.

Nasutitermes ephratae is very destructive in Panama, although apparently not quite as common as *N. cornigera*. Out-of-door, semispherical, "niggerhead," carton tree nests constructed of earth and excreted wood made by this species are apparently very rare in Panama.

At the Venado Plantation, Venado, Canal Zone, on August 10, 1921, Zetek and Molino found that almost all the coconut palms had tunnels of Nasutitermes on the trunks. Many palms had fairly large nests on the trunks just below the crown, where they were protected by the "lace." These termites also work freely between the sheaths of the frond petioles, mining well into the plant tissues of the trunk. They are very destructive and do not seem to confine their attack to sickly trees, but apparently any palm may be infested. They are abundant also on other trees in this grove. Workers and soldiers collected from a gallery proved to be *N. ephratae*.

INJURY TO ELECTRICAL INSULATION.

This termite has also affected electrical insulation. On November 29, 1921, a typical Nasutitermes termitarium, probably a secondary "nest," was discovered in a service box in a lamp-post. Specimens of the termites were collected by Zetek and Molino, with the assistance of E. St. Clair Clayton, who discovered the place, at Miraflores, Canal Zone, east wall, lake section, in concrete lamp-post No. 600.

These concrete lamp-posts have a bronze service box in which are two sockets for telephone service and one socket for a portable 110-volt light. They are covered with a bronze cover. The interior of the post is hollow. The wires to the telephone and light services come from a manhole opposite the post. In this case, this being the end post, the manhole is only about 2 feet deep. *Leucotermes tenuis* was collected in this service manhole.

The termitarium was back of the frame on which the telephone and light sockets were attached. It embraced all of the five wires and even covered parts of the frame and sockets (Pl. IX, *C*). This termitarium was about 15 inches in diameter and about 3 feet tall. The photograph of this service box shows only a portion of the nest.

The termites did not eat into the lead anywhere, although where the cable went through the termitarium the insects made a smooth whitish covering about it (Pl. VII, *B*). However, the cloth and rubber insulation were eaten, as was the weatherproofed braid from the wires leading to the overhead lights (Pl. IX, *E*). They do not care for copper and usually when the copper was made bare, they protected themselves from it by forming a sort of sheath of the same substance as the rest of the termitarium (Pl. VII, *D*). Much of this exposed copper wire was covered with verdigris.

The thickness of the rubber protection is almost 1.5 millimeters.

As soon as the nest was opened in the least, hordes of nasuti or soldiers came out to investigate. Whenever any one of these was touched or picked up with forceps, it emitted a drop of whitish liquid; sometimes it was squirted out, falling about 9 or 10 inches

away from the insect. There is a very pungent, nauseating odor about these termites.

No queens were found, although practically every bit of the nest was examined carefully. The number of workers and soldiers was simply stupendous. They walk either forward or backward with considerable speed. When uncovered on the ground, they crawl away in several columns, two or three termites abreast, and seek some dark place, into which they pour in great numbers.

Several pockets were found in the nest in which were a large number of very young termites. When these were disturbed certain workers began to pick them up and hasten away with them.

Specimens of this termite were also taken from galleries at the base of lamp-post 600 and were probably part of the nest in the service box.

POSSIBLE MECHANICAL CARRIAGE OF NEMATODE.

On February 23, 1922, Zetek and Molino found this termite working inside of the trunk of a 4-year-old live coconut palm (*Cocos nucifera*) back of house 259, Ancon, Canal Zone. This is an important observation, because Dr. N. A. Cobb, agricultural technologist of the United States Department of Agriculture, and Mr. Zetek had made inoculations into the roots and some petioles of this palm of the nematode *Aphelenchus cocophilus*, which causes "red-ring" disease of coconut palms. Later, when some of the infested roots were taken up, workers and nasuti of this termite were found. Thus species of Nasutitermes may prove to be mechanical carriers of this nematode.

It is a common sight in the Tropics and subtropics to see earthlike shelter galleries and carton "niggerhead" nests made by species of Nasutitermes on the trunks of coconut palms, the tubes running from base to crown like delicate graceful dark pencilings on the trunks and the nest often being in the tops of the trees. These termites also burrow into the wood of the trunks and sometimes in the West Indies the queen is in the wood of the tree rather than within the carton nest. Hence, if it should be proved that these termites are mechanical carriers of the nema, it would be a serious matter to eradicate them. Doctor Cobb kindly examined specimens of workers and soldiers of *Nasutitermes ephratae* taken from this infested palm at Ancon, but found no trace of the nematode *Aphelenchus cocophilus*. He says: "I think that you are right in suspecting that these ants might be carriers of this nema. Their habits would seem to put them under suspicion, but, at any rate in this case, they do not seem to have been carrying them."

Workers and nasuti of this termite were collected on a live fan palm on May 29, 1922, at Matias Hernandez, by Zetek.

A first-form queen of *Nasutitermes ephratae* collected in a small carton tree nest on a mango tree in an avocado plantation at Frijoles, Canal Zone, on February 19, 1921, by Zetek and Molino, measured 21 millimeters in length and 4.5 millimeters in width.

A large elliptical termitarium of *Nasutitermes ephratae*, 2 feet by 1½ feet in size, with tunnels leading to it, was found attached to the base of two petioles of a coconut palm at Corozal, Canal Zone, in a small coconut grove about 8 years old. On the ground was an-

other such termitarium, inhabited and almost as large, which, it appears, had been torn off of the tree by some men and left on the ground.

In the termitarium on the trunk were found soldiers (the most abundant form), then workers and young, and finally, all in one place but each within its own compartment, seven large, distended queens 19 to 23 millimeters in length and 4.5 millimeters in width. When disturbed, worker and soldier termites came to the queens and covered them up while others started to move them away to shelter.

The nest on the ground contained no queens, but was well inhabited with soldiers and workers, the former being most numerous.

Workers and soldiers of this termite, the latter very abundant, were found by Zetek and Molino in galleries on the trunk of a coconut palm at Corozal, Canal Zone, July 19, 1922, in the grove previously mentioned. The galleries, samples of which were saved, were from one-half to three-fourths inch wide, thin, and made of chewed wood.

This species works within the wood, and in numerous places holes were found leading into the palm trunk. The galleries all led to the top or crown of the palm, and were even sprawled over the petioles.

Most of the palms had termite tunnels of some sort, including small, narrow ones, one-fourth inch wide, made by *Eutermes* sp. Workers were found by Zetek and Molino in these small earthen galleries on the trunk of a coconut palm at Corozal, Canal Zone, July 19, 1922, in the same grove.

COMPOSITION OF SHELTER TUBES.

A microchemical examination of these shelter tubes of *N. ephratae* by the United States Bureau of Chemistry resulted in the following report:

Nasutitermes ephratae (M. 38248). The material submitted under this number was found to consist essentially of plant material, part of which gave the usual microchemical reaction for lignin. Siliceous material was practically absent.

NASUTITERMES COLUMBICUS Holmgren.

Nasutitermes columbicus apparently does not construct regular semispherical carton tree nests, but otherwise it does not differ in habits from *N. cornigera* and *N. ephratae*.

On October 25, 1921, at Frijoles, Canal Zone, Zetek and Molino found this termite on the trunk of an avocado tree. A vine grew along the tree trunk and was completely hollowed out by the termites. There were galleries along the trunk of the tree, but the termites did not enter the avocado wood. On the ground the tunnels were uncovered; these galleries were semicircular, three-fourths to three-eighths inch wide, and as much as three-eighths inch in height; they were of fine red granular dirt, thin, very fragile, of paperlike consistence. Termites were crawling about uncovered everywhere on the ground.

Nasutitermes columbicus also enters the wood of avocado trees. At Frijoles, Canal Zone, on February 4, 1922, galleries of this termite were found on an avocado tree (Plate X, *A*). These galleries were paperlike in texture, thin, and gray; they measured one-half

inch in width, and several galleries often coalesced to form a wide, flat one, 4 to 5 inches wide. The termites were also working inside of the wood, even in sound wood; in one place a termitarium of a sort was observed in the wood, but no queens were found.

SUBULITERMES ZETEKI Snyder.

This is a very interesting, odd appearing, nasutiform termite, but as yet little is known of its habits. The first record of this genus occurring in Central America was the capture of this species, named after J. Zetek, by Zetek and Molino at Summit, Canal Zone, on July 29, 1922. Workers and soldiers were found abundant in the trunk and petiole of an oil palm (*Elaeis melanococca*).

No species of Subulitermes occurs in the Dudley collection of Panama termites at the Museum of Comparative Zoology at Cambridge, Mass., nor in the Beaumont collection at the American Museum of Natural History in New York City.

EUTERMES DEBILIS Heer.

As yet little is known of the habits of *Eutermes debilis* in Panama. It has been found only on the Pacific slope. *E. debilis* builds earth-like galleries and earthen nests on the trunks of trees, including coconut palms. It is a wood borer.

At Ancon Hospital on October 26, 1921, Zetek and Molino found workers and soldiers of this termite in a tall tree. The whole trunk was covered with tortuous, light-brown to gray galleries, one-eighth to three-sixteenths inch wide. These galleries were of earth, firm, and often with algal growth over them. There was no nest, and the termites were few in number. Soldiers were scarce.

A nest found in the crotch of a mango tree on Taboga Island, Republic of Panama, on March 30, 1922, by Zetek and Molino was of hard clay (Pl. X, *B*) and of about one-fifth cubic foot content. Only one soldier was found; but workers were very abundant, as well as nymphs of the sexual forms with rudimentary wing pads. Two lots of eggs were found in oblong, shallow cells. A large first-form queen, with distended abdomen, was present. This queen is 21 millimeters in length and 4.5 millimeters in width.

On April 1 another nest of this species was found on Taboga Island in an orange tree, but few termites were present.

This termite is supposed to construct its nests and shelter tubes of dirt alone. However, fragments of shelter tubes of *Eutermes debilis* from the trunk of a tree at Ancon, Canal Zone, were examined by the Bureau of Chemistry with the following result:

> Sample *A*, M. 38191: This sample was found to contain an appreciable amount of siliceous material and also finely comminuted material which gave the usual microchemical reaction for lignin, but did not show any evidence of cellular structure.

It was remarked by the microanalyst that "apparently the so-called dirt in this instance may be in part decayed plant material, as the presence of lignified material would seem to indicate."

ANOPLOTERMES GRACILIS Snyder.

Very little is known of the habits of *Anoplotermes gracilis*. Apparently it does not construct a regular mound nest.

On February 18, 1922, Zetek collected workers and nymphs of the first form at Alhajuela, Republic of Panama, on the upper Chagres River basin. They were in claylike dirt under a stone at the base of a mango tree. There was no well-defined termitarium; the termites lived in burrows made in the clay. The long, white, slender nymphs were agile and moved about with ease. The termites did not penetrate the wood of the tree, so far as could be observed; their guts were filled with dirt.

TERMITE-LIKE SHELTER TUBES OF AN ANT.

In connection with the earthlike shelter tubes constructed by various species of termites, it is interesting to note that in Panama an ant forms termite-like carton shelter galleries along tree trunks (Pl. X, *D*). Specimens of this ant and the gallery substance were collected by Zetek and Molino on November 16, 1921, at Valdez's Place, Las Sabanas, near Panama City, Republic of Panama. This ant has been determined by Dr. W. M. Wheeler, of Bussey Institute, Harvard University, as *Azteca foreli* Emery.

The tree with these ant galleries on it was an old *Ficus* sp. about 8 feet in diameter, the top of it cut off squarely. The inside of the tree was well rotted. Along the outside (the bark was sound) ran many galleries, three-eighths to three-fourths inch in diameter, which at first sight looked like those of termites. They were, however, rough in appearance and very irregular in outline and were made of chewed-up pieces of wood. The inner surface is smoother, the outer rough. The old ones were colored by age, so that they resembled the color of the bark and even had algæ growing over them. The new galleries were distinctly of fresh-wood color. The ants were found wherever the tunnels were broken into, but there were a few places where the ants were unusually abundant. There were no signs of termites in the tree at the time.

Doctor Wheeler wrote:

> Before the ants arrived I was certain from his (Zetek's) description of the galleries that the specimens would prove to be *Cremastogaster stolli* Forel, but when they arrived I found that they were instead *Azteca foreli* Emery. I still believe that the galleries were probably constructed by the Cremastogaster, because I am quite familiar with that insect and its work, but that the Azteca had taken possession of them.

Doctor Wheeler further states that Forel (*4, p. 111*) was also of the opinion that these carton galleries on trees and rocks are really made by *Cremastogaster stolli*, but appropriated by *Azteca foreli*.

CONTROL.

Methods for the prevention of attack by termites have been given in some detail in a previous paper (*2, p. 300–301*). To generalize briefly:

In the construction of buildings or other structures, steel and stone or concrete should, where possible, supplant wood. All wood should be treated with chemical wood preservatives before being

placed in situ. Wooden forms should be removed after the concrete has hardened; when left, they become infested, and this leads to damage to woodwork, lead cables, etc. Where timber is to be used in contact with the ground, it should be impregnated with coal-tar creosote. The interior woodwork of buildings should also be impregnated with chemical wood preservatives; zinc chlorid, bichlorid of mercury, and chlorinated naphthalene[7] will protect wood from attack by termites, unless the situation is very damp, when the soluble chemicals, zinc chlorid and bichlorid of mercury, will leach out (*7*).

In the Philippine Islands a termite or "anay" exterminator has been found successful (*1, p. 58–59*). The method is as follows: To a 5-gallon can of kerosene oil, add 100 cubic centimeters of a saturated mixture of white arsenic in hydrochloric acid (HCL) (about 1 part acid to 1 part water). Tilt can so arsenic solution gathers at one corner. Then add 50 cubic centimeters concentrated sulphuric acid (H_2SO_4) which will withdraw water from the hydrochloric acid and will saturate the kerosene with hydrochloric-acid gas containing arsenic trichlorid. *This process is dangerous and should be done out in the open, and the operator must avoid breathing the fumes produced.* The process is completed after the reaction is stopped, and the solution is then ready for use. It is applied by painting or spraying on wood surfaces. Parts not exposed should be exposed and treated; it may also be injected into wood. Since this mixture will corrode the kerosene tin, it should be stored in a glass demijohn.

No wood known to the writers is immune to attack by termites, but there are many termite-resistant woods, and these should be used wherever possible. The heartwood of teak (*Tectona grandis*) from Siam and Burma; sal (*Shorea robusta*) of India; cypress pine (*Callitris robusta*) of Queensland, Australia; Foochow cedar (*Cunninghamia sinensis*) of China; Randai cedar (*Cunninghamia konishii*) of Formosa; greenheart (*Nectandra rodioei*) of South America; redwood (*Sequoia sempervirens*), incense cedar (*Libocedrus decurrens*), giant arborvitae or western red cedar (*Thuja plicata*),[8] and junipers or red cedars (*Juniperus* spp.) of the United States are woods which are very resistant to attack by termites, and there are many other such species.

Oshima (*6*) states that the resistance of the timbers which he tested to attack by termites is due to the presence of a sesquiterpene alcohol in the wood.

In the case of the subterranean mound-building termites, in addition to the remedial measures advocated by Dietz and Snyder (*2, p. 301*), it might be well to experiment with chloropicrin, one of the gases used with success in the World War. Feytaud (*3*) states that he has used this effectively in France against *Reticulitermes lucifugus* Rossi infesting the woodwork of buildings. Paradichlorobenzene might also prove effective in killing termites which construct

[7] The chlorinated naphthalene used in these tests is a mixture of various chlorinations as well as free naphthalene, with a large preponderance, however, of tri chlor naphthalene. This material is usually referred to as tri chlor naphthalene, and as compared with other chemicals it is really comparable to a technical product having naphthalene, mono chloro naphthalene, di chlor naphthalene, and probably some of the higher chlorinations as impurities. Its melting point ranges between 190° and 210° F. This is the specification under which it is sold.

[8] Red cedar poles are badly attacked by Katotermes in California.

mound nests or which have underground galleries with well-defined openings. This chemical is a coal-tar product made by combining benzol and chlorine gas. Crystals could be placed in the openings of the nests or mounds and thus kill subterranean termites. However, where a large number of termite mounds occur on land intended for cultivation, the land can be cleared by the use of steam shovels or by exploding the mounds with dynamite and crushing them by a heavy gasoline caterpillar tractor. The soil can then be sprayed with sodium cyanid to kill the termites, using 160 pounds of granular sodium cyanid per acre with 12,000 gallons of water, as recommended for the Japanese beetle (*Popillia japonica* Newm.), or quicklime, wood ash, or lye used.

Species in the family Kalotermitidae probably can be practically controlled by the use of dry heat. In the attic of the Royal Palm Hotel, a large, high, frame structure at Miami, Fla., the temperature becomes very high, due to the subtropical heat and also to the fact that the sun's rays beat down on the roof; the temperature in the attic was from 17° to 24° F. higher than the maximum temperature recorded by the United States Weather Bureau. Oak and maple furniture infested with the destructive West Indian termite *Cryptotermes brevis* Walker, which had been removed from guest rooms and placed in this attic directly under the roof, contained no living termites when examined in the latter part of January and early part of February, 1922, by T. E. Snyder. Small piles of pellets under this furniture indicated that the termites had continued to work in the infested furniture for a short period after having been removed to the attic, where undoubtedly the temperature became too great even for a termite that normally lives in hard dry wood, i. e., in wood which probably contains normally only about 10 per cent of moisture.

O'Kane and Osgood (*5*) were successful in killing the earth-inhabiting termite *Reticulitermes flavipes* Kol. which was infesting the woodwork of a large hospital at Dover, N. H., by the use of supplementary steam piping and maintaining a temperature of 135° F. for 24 hours.

Fumigation with hydrocyanic-acid gas will kill species of Kalotermitidae infesting woodwork of buildings or furniture. Twelve ounces of sodium cyanid per 1,000 cubic feet was successfully used in killing *Cryptotermes brevis* Walker infesting woodwork and furniture in case of the Royal Palm Hotel at Miami, after the building had been sealed; the gas remained in the building for about 48 hours.

In order to kill termites of the family Kalotermitidae which work in dry wood and have no connection with the ground, various mixtures can be used. A 20 to 30 per cent solution of paradichlorobenzene in kerosene (or orthodichlorobenzene, a similar chemical) can be used effectively.

The infested wood is saturated with this liquid by swabbing it with a mop. Several treatments may be necessary to enable the chemicals to penetrate the wood and kill the insects therein. A poisoned kerosene-emulsion mixture can be similarly used by dissolving 1 ounce of sodium arsenite in each gallon of the water used for diluting stock mixtures of kerosene emulsion or miscible oil.

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